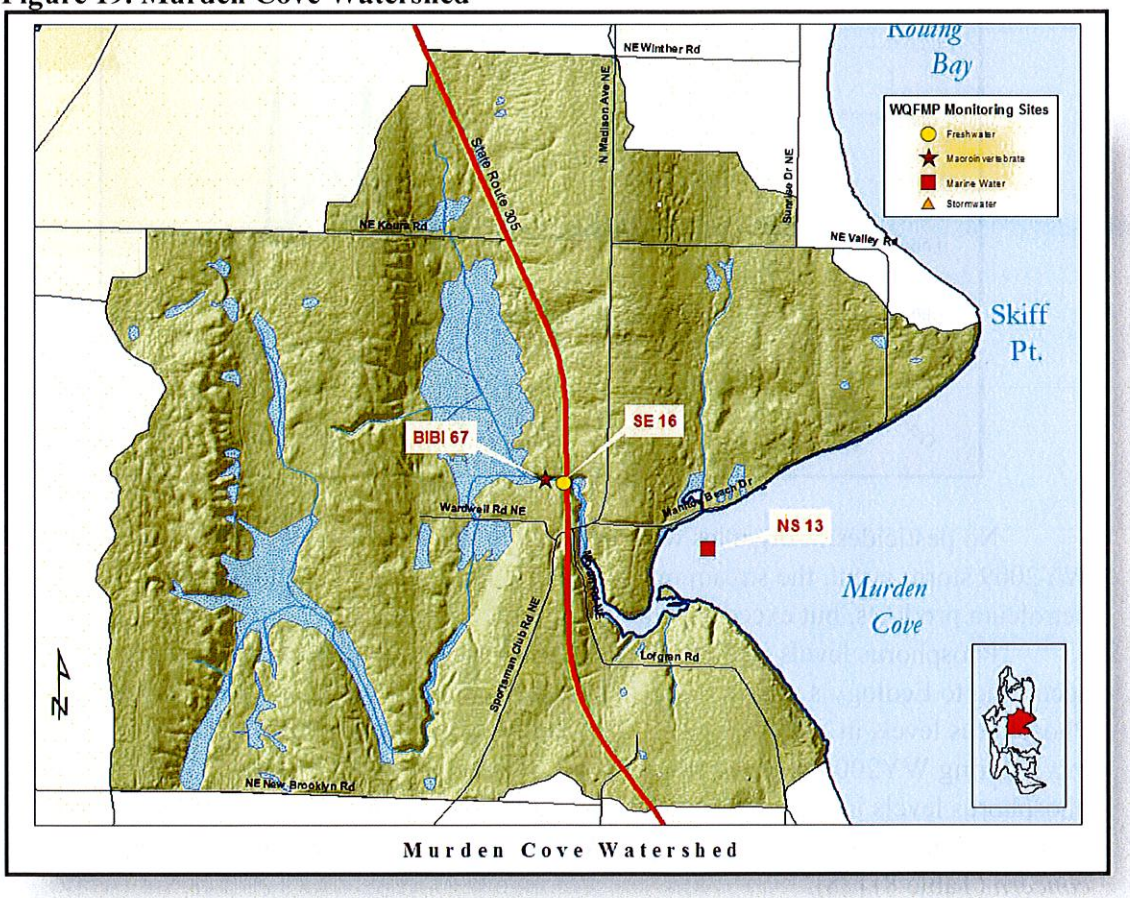
Murden Cove Watershed

At a size of 2,041 acres, the Murden Cove watershed is one of the largest watersheds on the Island. Land use within this basin consists of various densities of residential, commercial, light industrial, schools, and a portion of the Rolling Bay Neighborhood Service Center. The watershed encompasses 2.2 miles of State Highway 305 and 146 acres of park. There are agriculture and livestock farms spread throughout the basin. Most land uses in this basin utilize onsite septic systems, but sanitary sewer services are provided for a portion of the basin (Figure 19).

Figure 19. Murden Cove Watershed



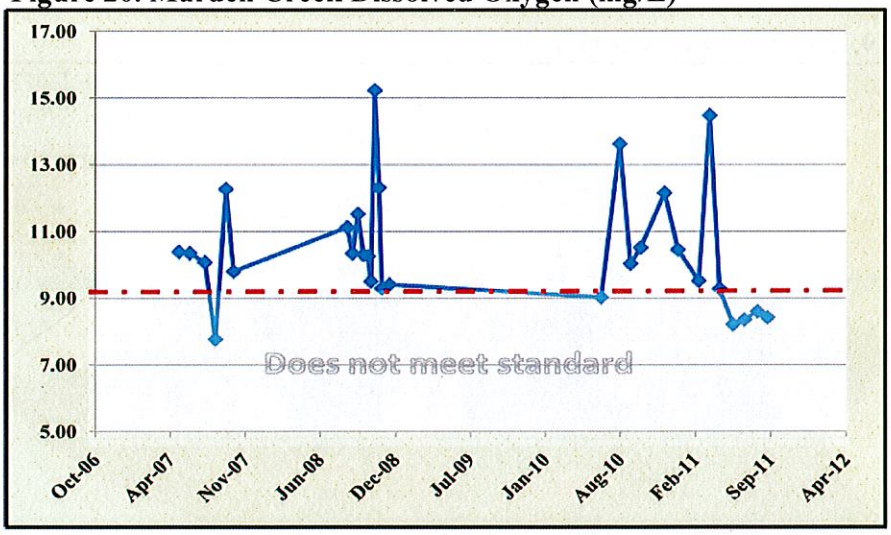
Freshwater

The primary stream in the watershed, Murden Creek, is one of the Island's eight combined stream networks, comprised of a mainstem and two significant tributaries (Woodward Creek and Meig's Creek) totaling 3.7 stream miles. Along with several smaller drainages directly to the shoreline, Murden Creek delivers drainage to Murden Cove which encompasses the entire 3.3-mile shoreline of the watershed.

The WQFMP established a monitoring site on Murden Creek at the State Highway 305 crossing as part of the pilot study and early program implementation and continued status and trends monitoring at the site in WY2010 and WY2011 (SE16). The City also established a benthic macroinvertebrate sampling site immediately upstream of SE16 (BIBI 67) (Figure 19).

The City's monitoring results from Murden Creek showed that although the stream regularly met the standard for temperature and pH, it frequently fell below the standard for dissolved oxygen (9.5 mg/L) (Figure 20).

Figure 20. Murden Creek Dissolved Oxygen (mg/L)



No pesticides or organics were detected in the stream in WY2007. During a WY2009 storm event, the stream met all criteria for metals and had no detections of petroleum products, but exceeded chronic criteria for ammonia.

Phosphorus levels in Murden Creek were generally of *moderate concern* according to Ecology's stream WQI, in keeping with all other Island streams measured. Phosphorus levels in WY2007 were 0.076 mg/L during the dry season and 0.070 – 0.080 mg/L during WY2009 targeted storm events. However, in WY2010 and WY2011, total phosphorus levels increased to range from 0.29 mg/L to 1.6 mg/L, the second highest concentration on the Island. Ecology's WQI scored these concentrations of *highest concern* (Table 8) [28].

Nitrogen levels in Murden Creek were also in keeping with Island wide averages, elevating somewhat in WY2010 and increasing in WY2011. Nitrite concentrations in WY2009 were 0.010 mg/L and 0.013 mg/L. Nitrate concentrations from targeted storm event sampling in WY2009 were between 0.113 mg/L and 0.228 mg/L. Dry season values in WY2010 and WY2011 were 0.280 mg/L and 0.235 mg/L, respectively. WY2011 wet season nitrate concentration was 0.746 mg/L.

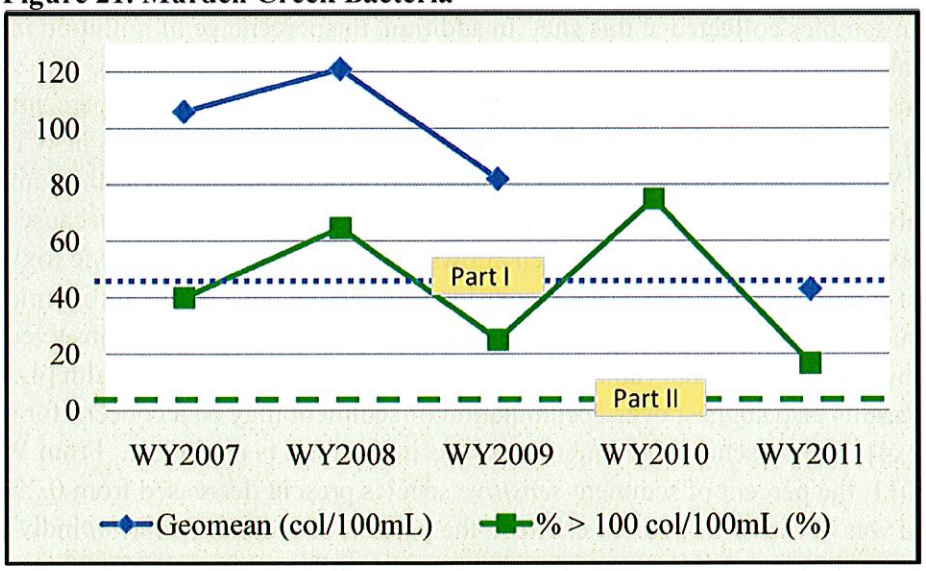
There are no established standards for nutrients. However, continued monitoring may be useful as increases in these levels may indicate increased nutrient-loading from

upstream illicit discharges which may be contributing to observed low dissolved oxygen and increasing algal growth in Murden Cove.

Bacterial concentrations in Murden Creek were also elevated. In WY2007-2010 Murden Creek consistently failed to meet the standard with annual geomeans ranging from 82 – 121 col/100 mL. In WY2011, the stream met Part I of the standard with an annual geomean of 43 col/100 mL. However, two of the twelve samples (16.7%) exceed 100 col/100 mL, failing to meet Part II of the standard (Figure 21).

Note that Part I of the criteria is represented by the blue dashed line in Figure 21, and Part II of the criteria is represented by the green dashed line. Geomean data represented by blue diamonds must fall below the blue dashed line, **and** percent data represented by green squares must fall below the green dashed line to meet the criteria.

Figure 21. Murden Creek Bacteria



Murden Creek had an average conductivity of 140 µS/cm and maximum of 304 µS/cm similar to other freshwater values on the Island. The stream's average turbidity of 7.0 NTU was in keeping with Island wide freshwater averages. However, Murden Creek's maximum turbidity, 77.1 NTU (measured during storm events), was the highest stream value measured by the City and far exceeds the 25 NTU benchmark beyond which fish habitat is impaired (Figure 3).

These results agreed with observed impacts to the macroinvertebrate community residing on and in the stream bed. The overall B-IBI scores for Murden Creek were 21 in WY2008, 20 in WY2010, and 21 in WY2011, indicating poor conditions (Figure 6). The change in overall B-IBI scores across the three sampled years was not considered a statistically-significant change. Per Doberstein et al. [5], when comparing the B-IBI scores for a site between two different sampling years, the difference between the two B-IBI scores must be greater than 4 to conclude that there is a biological difference between the two years. The B-IBI score difference between all the sampled years (WY2008,

WY2010, and WY2011) was only one. Thus, results from the three sampling years indicated the overall poor biological condition for Murden Creek did not change between WY2008 and WY2011.

However, thorough analysis of the metric values (or scores) used to derive the overall B-IBI scores showed significant changes in some of the metrics themselves. Out of the ten metric values used to calculate the overall score, the metrics that appeared to most heavily impact the overall score were the Pollution Tolerant and Intolerant Percents, Pollution Sensitive Richness, Sediment Sensitive Percent, Sediment Tolerant Percent, and the Metals Tolerance Index.

From WY2008 to WY2011, both the Pollution Intolerant Percent (percent of total population) and Pollution Sensitive Richness (number of species present) decreased. Pollution *in*tolerant species decreased from 22% to 5%, and the Pollution Sensitive Richness decreased from 1.0 to 0.7. Only one or no pollution *sensitive* species were present in samples collected at this site. In addition, the percentage of pollution *in*tolerant individuals dropped dramatically from 29% in WY2010 to 5% in WY2011.

In addition to a decrease in the pollution *in*tolerant population, the percentage of pollution *tolerant* species, such as Chironomidae [4, 7], increased from 1% in WY2008 to 2% in WY2011, and *supertolerant* species increased from 11% to 15%. Chironomidae, commonly called midges, are frequently found in highly-polluted waters, because some midge larvae produce hemoglobin which allows them to live in nearly anoxic (oxygen-depleted) conditions [4, 7, 15]. This increasing trend in the percent of Chironomidae in the benthic community combined with the chronically-low oxygen levels observed in the in-situ physiochemical data (Table 6) are indicative of degraded stream health [4, 9].

Results also suggest over-accumulation of sediment may be a concern for Murden Creek [2, 4]. The presence of sediment *sensitive* individuals is negligible. From WY2008 to WY2011, the percent of sediment *sensitive* species present decreased from 0.2% to 0.1% and was 0% in WY2010. In contrast, the percent of sediment *tolerant* individuals present ranged from 7-14%. Out of the nine samples collected from WY2008 to WY2011, only four had one sediment *in*tolerant species present. The other five samples had none. Conversely, up to three sediment *tolerant* species were present in each sample.

The lack of sediment *sensitive* species, the presence of sediment *tolerant* species, the high turbidity measurements during rain events, and the sand-dominated stream bed at the sampling site indicated excess sediment was impacting biological conditions in Murden Creek.

Analysis of the Metals Tolerance Index indicated that heavy metals may be influencing stream biological health. The B-IBI scoring criteria for this metric considers sites with Metals Tolerance Index values greater than 4 to be impacted (with 10 being the maximum) [1, 2]. The Metals Tolerance Index for Murden Creek increased from 2.8 in WY2008 to 3.3 in WY2011. Although no exceedances in aluminum, copper, lead, or zinc were observed, other metals that were not measured such as mercury, cadmium, or chromium may be responsible for the increase in this metric.

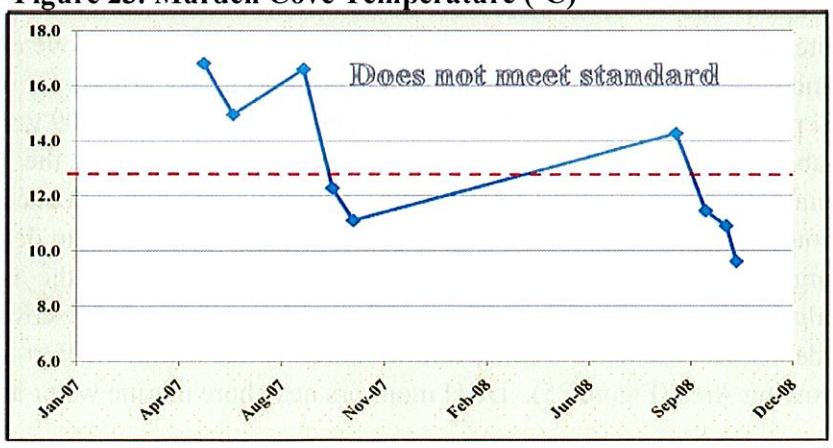
Marine Water

Ecology's *2008 Water Quality Assessment* did not list any of the watershed's surface waters as *Waters of Concern* or *Impaired*, except Murden Cove where aquatic habitat has been listed *Impaired* by low oxygen levels since 2004. Ecology's *2008 Water Quality Assessment* categorized habitat in Murden Cove as "4c" (Impaired, but a TMDL would be inappropriate) stating "Frankenstein, 2000. show the continuous cover of ulvoid macroalgae are impairing aquatic life from identified human causes at Murden Cove" as the basis for the listing [19]. Ecology's draft 2010 assessment listed Murden Cove as *Impaired* by bacteria, as well (Table 1) [20].

The City monitored one nearshore area in Murden Cove as part of the WQFMP pilot study and early implementation (NS13) (Figure 19). Monitoring results showed significant impairment in Murden Cove. The cove periodically exceeded pH criteria, and frequently failed to meet dissolved oxygen (7.0 mg/L) and temperature (13°C) criteria (Figure 22 and 23).

Figure 22. Murden Cove Dissolved Oxygen (mg/L)

Figure 23. Murden Cove Temperature (°C)

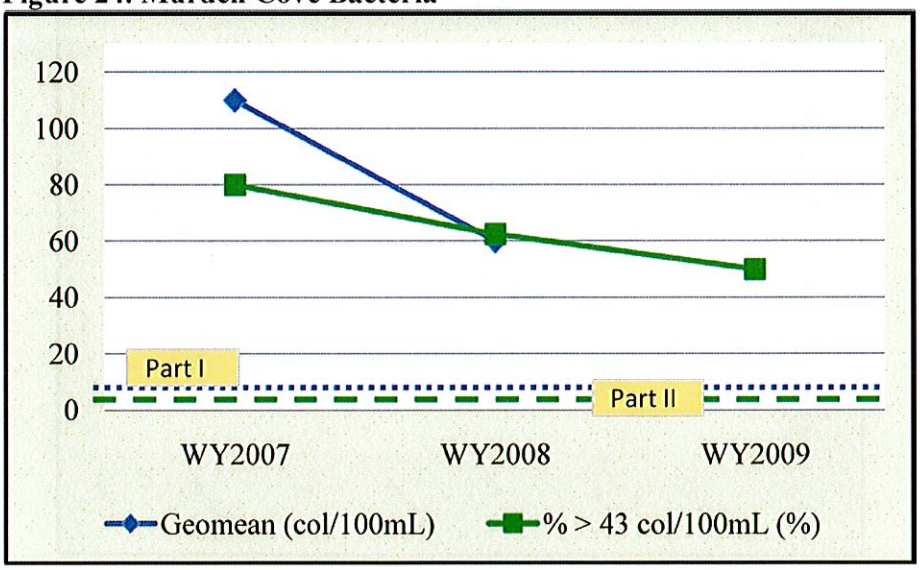


Although its average turbidity, 9.1 NTU, was relatively low, the maximum value measured during rain events was 45.7 NTU, well above the 25 NTU benchmark at which fish habitat is impacted, likely due to the high turbidity from Murden Creek (Figure 3).

The cove failed to meet the bacteria criteria all three years it was monitored. In WY2007, a geomean of 110 col/100 mL far exceeded Part I of the criteria (14 col/100 mL), and four of five samples (80%) had concentrations greater than 43 col/100 mL, exceeding Part II of the standard. In WY2008, the cove had a geomean of 60 col/100 mL, and ten out of sixteen samples (62.5%) exceeded 43 col/100 mL. In WY2009, only four samples were collected, so no geomean could be calculated, but two out of four samples (50%) exceeded 43 col/100 mL (Figure 24).

Note that Part I of the criteria is represented by the blue dashed line in Figure 24, and Part II of the criteria is represented by the green dashed line. Geomean data represented by blue diamonds must fall below the blue dashed line, **and** percent data represented by green squares must fall below the green dashed line to meet the criteria.

Figure 24. Murden Cove Bacteria



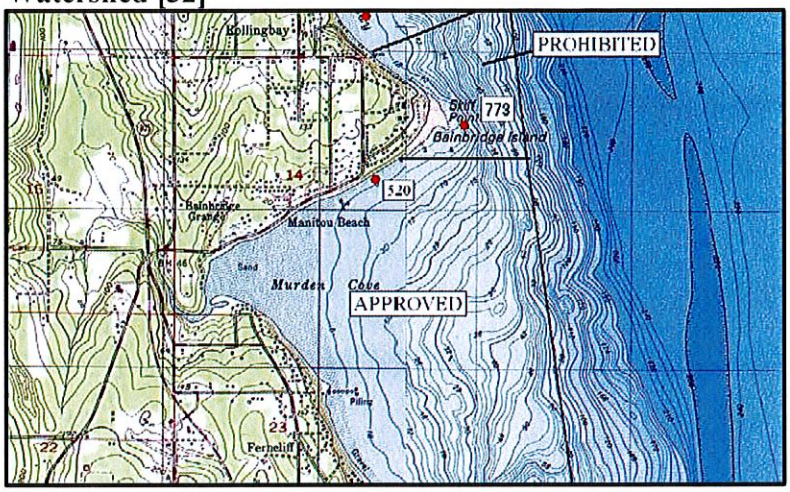
In WY2007 and WY2009 there were no detections of petroleum products, and the cove met criteria for lead. However, during WY2009 storm events, the cove exceeded both acute and chronic criteria for ammonia and exceeded chronic criteria for copper.

Total phosphorus during targeted storm event sampling in WY2009 was 0.17 - 0.18 mg/L, about average for most nearshore marine waters monitored on the Island. However, total nitrogen measured 1.08 – 1.57 mg/L, some of the highest concentrations measured around the Island (Table 9). Continued monitoring is required to determine if illicit discharges are contributing to nutrient-loading which is supporting the increasing springtime algal blooms and year-round cover of ulvoid macroalgae in the cove.

Murden Cove Watershed's entire 2-mile shoreline lies within the Port Madison Shellfish Growing Area (Figure 25). DOH monitors nearshore marine water at two sites

in the watershed, #520 offshore of the NE Manitou Beach Road/NE Manitou Park Boulevard intersection and #773 off Skiff Point. Site #520 has consistently met the standard for bacteria. DOH had not reported results for #773, a fairly new station, at the time of this printing. Apart from a small area around Skiff Point which includes a sewer outfall exclusionary zone, all other nearshore areas are approved for shellfish harvest.

Figure 25. Port Madison Shellfish Growing Area in the Watershed [32]



The City partnered with Kitsap County Health District to conduct shoreline drainage surveys from Port Madison Bay to Murden Cove in 2012 - 2014 (see *EPA Shellfish Restoration and Protection Project*, page 72).

Stormwater

The City did not monitor any stormwater drainages in this watershed.